# Accurate phase estimation in holographic interferometry

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## Aim

To develop fringe analysis techniques that are capable of providing a direct estimation of the unwrapped phase distributions from *a single fringe pattern*, with an accuracy that is in par with that can be obtained with phase shifting methods.

## Introduction

•In interferometric applications, accurate estimation of the phase map from the recorded interferograms, plays a vital role in deciding the accuracy of measurements, such as displacement, shape or surface deformation.

• Over last three decades, several phase estimation methods (often referred to as fringe analysis techniques) have been developed; broadly they can be categorized as temporal and spatial analysis techniques.

•Temporal analysis techniques are known for their ability to estimate phase with greater accuracy than the existing spatial analysis techniques, but are not applicable for dynamic measurements, as they require large number of images/interferograms to be recorded for making a single measurement.

•Spatial analysis techniques are capable of estimating the phase map from a single fringe pattern. However, when analyzing patterns similar to the one shown in Fig.1(a), the results obtained with the existing spatial techniques are found to be unsatisfactory.

•All these methods, either temporal or spatial analysis methods generate wrapped phase maps, which need to be further unwrapped in order to obtain an estimation of true phase map.

## Achievement

We have developed a novel interferometric phase estimation method that is capable of producing directly the accurate unwrapped phase distribution from a single fringe pattern. It is interesting to note that under certain conditions, this method provides, from a single frame, the estimation of the phase with an accuracy that can only be obtained by high-resolution phase shifting methods using about 10 data frames.

## Simulation Results

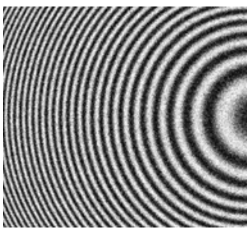

Fig.1(a) Simulated fringe pattern

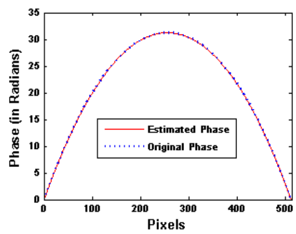


Fig.1(b) Phase estimated using the proposed method along middle row, after removing the carrier

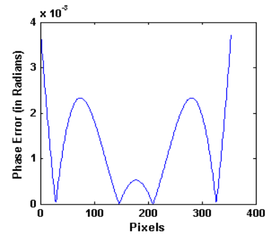


Fig.1(c) Error plot

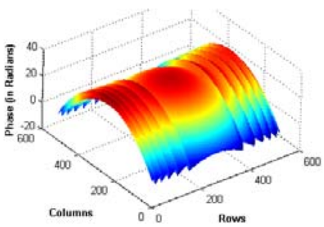


Fig.1(d) 3D plot of estimated phase along all rows

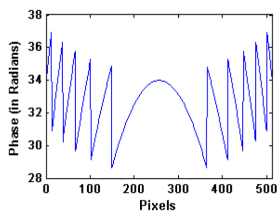


Fig.1(e) Profile of the reconstructed phase along the middle column

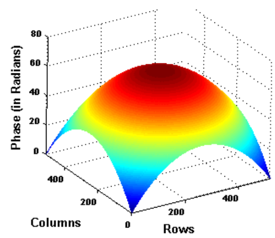


Fig.1(f) 3D plot of the resulting phase map after Phase stitching

## Experimental Results

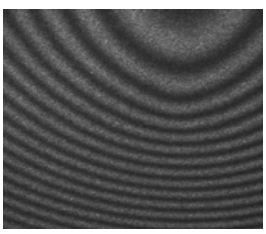

Fig.2(a) Experimentally recorded holographic fringe pattern

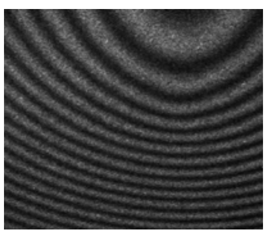

Fig.2(b) Fringe pattern after eliminating d.c.

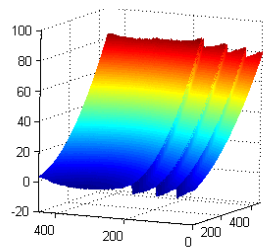

Fig.2(c) 3D plot of the phase estimated, from Fig.2(b), along all rows using the proposed fringe analysis method

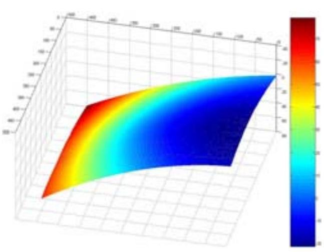

Fig.2(d) 3D plot of the resulting phase map after Phase stitching

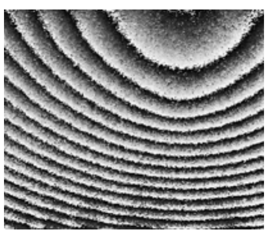

Fig.2(e) Phase calculated directly from the *analytic signal* using *arctan* function.

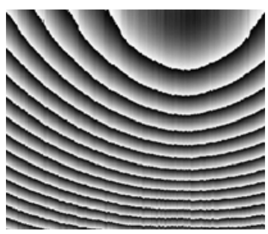

Fig.2(f) Wrapped phase map generated from Fig.2(d) (for the sake of comparing quality of results obtained)